CATION PUBLISHED UNDER THE PATENT COCLERATION TREATY (PCT)

(19) World Intellectual Property **Organization**

International Bureau



(43) International Publication Date 5 August 2004 (05.08.2004)

PCT

(10) International Publication Number WO 2004/065986 A3

(51) International Patent Classification7:

G01V 1/38

(21) International Application Number:

PCT/US2003/032256

- (22) International Filing Date: 10 October 2003 (10.10.2003)
- (25) Filing Language:

(26) Publication Language:

English

(30) Priority Data: 60/440,565

16 January 2003 (16.01.2003)

- (71) Applicant (for all designated States except US): EXXON-MOBIL UPSTREAM RESEARCH [US/US]; P.O. Box 2189, Houston, TX 77252-2189 (US).
- (72) Inventors; and
- (75) Inventors/Applicants (for US only): DUREN, Richard, E. [US/US]; 10 Claridge Court, Conroe, TX 77304 (US). MEIER, Mark, A. [US/US]; 3133 Buffalo Speedway, Apt. 2201, Houston, TX 77098 (US).
- (74) Agents: KATZ, Gary, P. et al.; ExxonMobil Upstream Research Company, P.O. Box 2189, Houston, TX 77252-2189 (US).

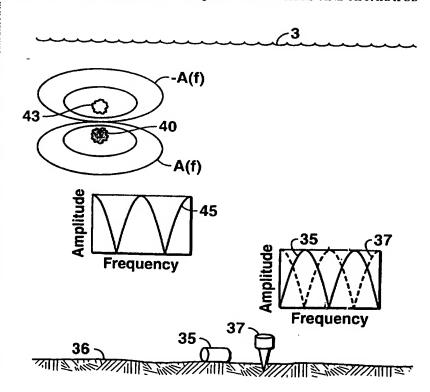
- (81) Designated States (national): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.
- (84) Designated States (regional): ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PT, RO, SE, SI, SK, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii)) for the following designations AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD. MG, MK, MN, MW, MX, MZ, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SY, TJ, TM, TN,

[Continued on next page]

(54) Title: A MARINE SEISMIC ACQUISITION METHOD AND APPARATUS



(57) Abstract: A marine seismic source method capable of retaining low frequencies is disclosed. One embodiment of the method comprises a seismic source that generates an up-going wave and first down-going wave with opposite polarity. up-going wave reflects off the ocean surface as a second down-going wave having the same polarity as the first down-going wave and the first and second down-going waves combine substantially in-phase to form a third down-going wave. A source apparatus to accomplish the method is also disclosed. One source apparatus embodiment comprises a device wherein at least part of the device is below the surface of the water and the device is adapted to cause oscillations below the surface of the water, and means for oscillating the device in the water to create an up-going wave and a first down-going wave and the up-going wave has reverse polarity relative to the first down-going wave.



TR, TT, TZ, UA, UG, UZ, VC, VN, YU, ZA, ZM, ZW, ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PT, RO, SE, SI, SK, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG)

- as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii)) for the following designations AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, UZ, VC, VN, YU, ZA, ZM, ZW, ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, BG, CH, CY,
- CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PT, RO, SE, SI, SK, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG)
- as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii)) for the following designation US
- as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii)) for the following designation US
- of inventorship (Rule 4.17(iv)) for US only

Published:

- with international search report
- (88) Date of publication of the international search report:
 7 October 2004

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US03/32256

IPC(7)	Commercial		FC1/USU3/32230	
	ASSIFICATION OF SUBJECT MATTER : G01V 1/38			
US CL	: 367/15, 324/365			
	o International Patent Classification (IPC) or to both	national classification and	TPC	
B. FIEI	LDS SEARCHED	THE HOLDSTROME OF THE PARTY OF	нс	
Minimum de	ocumentation searched (classification system followed	d by classification symbols	2)	
U.S. : 3	367/15	a by classification symbols	•)	
				•
Documentati	ion searched other than minimum documentation to the	ho ovrtome that and the		
	The second of the second secon	ne extent mat such docume	ents are included in	n the fields searched
731				
Electronic da	ata base consulted during the international search (na	me of data base and, wher	e practicable, sear	ch terms used)
			_	
	CUMENTS CONSIDERED TO BE RELEVANT			
Category *	Citation of document, with indication, where	appropriate, of the relevan	nt passages	Relevant to claim No.
. X, E	US 6,678,207 B2 (DUREN) 13 January 2004 (13.0	01.2004), see column 4, li	nes 8-44.	1-28
			•	
			1	
			1	
			ſ	
İ			ļ	
			[
	,		İ	
,			j	
			j	
Further	documents are listed in the continuation of Day C			,
	documents are listed in the continuation of Box C.	See patent fan	_	
Sp	pecial categories of cited documents:	"T" later document p	ublished after the interr	national filing date or priority
Sr A" document	pecial categories of cited documents: defining the general state of the art which is not considered to be	"T" later document p	ublished after the interr	tion but cited to understand the
Sr A" document of particul	pecial categories of cited documents: defining the general state of the art which is not considered to be lar relevance	"T" later document p date and not in c principle or theor	ublished after the interr onflict with the applicat ry underlying the inven	tion but cited to understand the tion
Sr A" document of particul	pecial categories of cited documents: defining the general state of the art which is not considered to be	"T" later document p date and not in c principle or theo "X" document of part considered novel	ublished after the interr onflict with the applicat ry underlying the inven icular relevance; the cla or cannot be considere	tion but cited to understand the
A" document of particul E" earlier app	pecial categories of cited documents: defining the general state of the art which is not considered to be lar relevance plication or patent published on or after the international filing date which may throw doubts on priority claim(s) or which is cited to	"T" later document p date and not in c principle or theo "X" document of part	ublished after the interr onflict with the applicat ry underlying the inven icular relevance; the cla or cannot be considere	tion but cited to understand the tion
A" document of particul E" earlier app L" document establish the	pecial categories of cited documents: defining the general state of the art which is not considered to be lar relevance plication or patent published on or after the international filing date which may throw doubts on priority claim(s) or which is cited to he publication date of another citation or other special reason (as	"T" later document p date and not in c principle or theo "X" document of part considered novel when the document "Y" document of part	ublished after the interr onflict with the applicat ry underlying the inven- icular relevance; the cla or cannot be considere ent is taken alone	aimed invention cannot be
'A" document of particul E" earlier app L" document establish the specified)	pecial categories of cited documents: defining the general state of the art which is not considered to be lar relevance plication or patent published on or after the international filing date which may throw doubts on priority claim(s) or which is cited to he publication date of another citation or other special reason (as	"T" later document p date and not in c principle or theor "X" document of part considered novel when the documen "Y" document of part considered to inv	ublished after the interr onflict with the applicat ry underlying the inven- cicular relevance; the el- or cannot be considere ent is taken alone icular relevance; the el-	aimed invention cannot be d to involve an inventive step
A" document of particul E" earlier app L" document establish the specified)	pecial categories of cited documents: defining the general state of the art which is not considered to be lar relevance plication or patent published on or after the international filing date which may throw doubts on priority claim(s) or which is cited to he publication date of another citation or other special reason (as	"T" later document p date and not in c principle or theor "X" document of part considered novel when the documen "Y" document of part considered to inv combined with or	ublished after the interr onflict with the applicat ry underlying the inven- cicular relevance; the el- or cannot be considere ent is taken alone icular relevance; the el-	aimed invention cannot be d to invention cannot be d to involve an inventive step
A" document of particul E" earlier app L" document establish the specified) O" document P" document	pecial categories of cited documents: defining the general state of the art which is not considered to be lar relevance plication or patent published on or after the international filing date which may throw doubts on priority claim(s) or which is cited to he publication date of another citation or other special reason (as referring to an oral disclosure, use, exhibition or other means published prior to the international filing date but later than the	"T" later document p date and not in c principle or theor "X" document of part considered novel when the document "Y" document of part considered to inv combined with or being obvious to	ublished after the interr onflict with the applicat ry underlying the inven- cicular relevance; the cla- or cannot be considere ent is taken alone icular relevance; the cla- olve an inventive step vance or more other such da a person skilled in the a	tion but cited to understand the tion aimed invention cannot be d to involve an inventive step aimed invention cannot be when the document is locuments, such combination art
A" document of particul E" earlier app L" document establish the specified) O" document P" document priority da	pecial categories of cited documents: defining the general state of the art which is not considered to be lar relevance plication or patent published on or after the international filing date which may throw doubts on priority claim(s) or which is cited to the publication date of another citation or other special reason (as referring to an oral disclosure, use, exhibition or other means published prior to the international filing date but later than the te claimed	"T" later document p date and not in c principle or theor "X" document of part considered novel when the document "Y" document of part considered to inv combined with or being obvious to "&" document member	ublished after the interr onflict with the applicat ry underlying the inven- icular relevance; the cla- or cannot be considere ent is taken alone icular relevance; the cla- olve an inventive step vance or more other such da a person skilled in the a	aimed invention cannot be d to involve an inventive step aimed invention cannot be d to involve an inventive step aimed invention cannot be when the document is locuments, such combination art
A" document of particul E" earlier app L" document establish the specified) O" document P" document priority da	pecial categories of cited documents: defining the general state of the art which is not considered to be lar relevance plication or patent published on or after the international filing date which may throw doubts on priority claim(s) or which is cited to he publication date of another citation or other special reason (as referring to an oral disclosure, use, exhibition or other means published prior to the international filing date but later than the	"T" later document p date and not in c principle or theor "X" document of part considered novel when the document "Y" document of part considered to inv combined with or being obvious to "&" document member	ublished after the interr onflict with the applicat ry underlying the inven- icular relevance; the cla- or cannot be considere ent is taken alone icular relevance; the cla- olve an inventive step vance or more other such da a person skilled in the a	aimed invention cannot be d to involve an inventive step aimed invention cannot be d to involve an inventive step aimed invention cannot be when the document is locuments, such combination art
A" document of particul E" earlier app L" document establish the specified) O" document priority da Date of the acc	defining the general state of the art which is not considered to be lar relevance plication or patent published on or after the international filing date which may throw doubts on priority claim(s) or which is cited to the publication date of another citation or other special reason (as referring to an oral disclosure, use, exhibition or other means published prior to the international filing date but later than the see claimed	"T" later document p date and not in c principle or theor "X" document of part considered novel when the document "Y" document of part considered to inv combined with or being obvious to "&" document membe	ublished after the interronflict with the applicative underlying the inventional relevance; the client is taken alone icular relevance; the client is taken alone icular relevance; the client of the an inventive step when or more other such da person skilled in the act of the same patent faronternational search	aimed invention cannot be d to involve an inventive step aimed invention cannot be d to involve an inventive step aimed invention cannot be when the document is locuments, such combination art
A" document of particul E" earlier app L" document establish the specified) O" document priority da Date of the accument approach and a control to the accument approach and a	defining the general state of the art which is not considered to be lar relevance plication or patent published on or after the international filing date which may throw doubts on priority claim(s) or which is cited to the publication date of another citation or other special reason (as referring to an oral disclosure, use, exhibition or other means published prior to the international filing date but later than the see claimed ctual completion of the international search	"T" later document p date and not in c principle or theor "X" document of part considered novel when the document "Y" document of part considered to inv combined with or being obvious to "&" document membe	ublished after the interronflict with the applicative underlying the inventicular relevance; the classic content is taken alone icular relevance; the classic colve an inventive step valor more other such da person skilled in the atternational search	aimed invention cannot be d to involve an inventive step aimed invention cannot be aimed invention cannot be aimed invention cannot be when the document is locuments, such combination art mily
A" document of particul E" earlier app L" document establish the specified) O" document priority da Date of the accument application of the ac	defining the general state of the art which is not considered to be lar relevance plication or patent published on or after the international filing date which may throw doubts on priority claim(s) or which is cited to the publication date of another citation or other special reason (as referring to an oral disclosure, use, exhibition or other means published prior to the international filing date but later than the use claimed trual completion of the international search (21.04.2004) iling address of the ISA/US Stop PCT, Atm: ISA/US	"X" document of part considered novel when the document of part considered to inv combined with or being obvious to document member of mailing of the in Authorized officer	ublished after the interronflict with the applicative underlying the inventicular relevance; the classic content is taken alone icular relevance; the classic colve an inventive step valor more other such da person skilled in the atternational search	aimed invention cannot be d to involve an inventive step aimed invention cannot be aimed invention cannot be aimed invention cannot be when the document is locuments, such combination art mily
A" document of particul E" earlier app L" document establish the specified) O" document priority da document document priority da date of the act of the a	defining the general state of the art which is not considered to be lar relevance plication or patent published on or after the international filing date which may throw doubts on priority claim(s) or which is cited to the publication date of another citation or other special reason (as referring to an oral disclosure, use, exhibition or other means published prior to the international filing date but later than the see claimed citual completion of the international search (21.04.2004) illing address of the ISA/US Stop PCT, Atm: ISA/US missioner for Patents	"T" later document p date and not in c principle or theor "X" document of part considered novel when the document "Y" document of part considered to inv combined with or being obvious to "&" document membe	ublished after the interronflict with the applicative underlying the inventicular relevance; the classic content is taken alone icular relevance; the classic colve an inventive step valor more other such da person skilled in the atternational search	aimed invention cannot be d to involve an inventive step aimed invention cannot be diversely aimed invention cannot be when the document is locuments, such combination art
A" document of particul E" earlier app L" document establish the specified) O" document priority da loate of the act of t	pecial categories of cited documents: defining the general state of the art which is not considered to be lar relevance plication or patent published on or after the international filing date which may throw doubts on priority claim(s) or which is cited to he publication date of another citation or other special reason (as referring to an oral disclosure, use, exhibition or other means published prior to the international filing date but later than the ate claimed cual completion of the international search (21.04.2004) lling address of the ISA/US Stop PCT, Attn: ISA/US missioner for Patents Box 1450	"X" document of part considered novel when the document of part considered to involve the considered to involve the considered to involve the document of part considered to involve the document with or being obvious to document member document member and the considered to involve the considered t	ublished after the interronflict with the applicative underlying the inventicular relevance; the classical relevance; the classical relevance; the classical relevance; the classical relevance; the classical relevance; the classical relevance; the classical relevance; the classical relevance in the same patent fair of the same patent fair relevance relevance.	aimed invention cannot be d to involve an inventive step aimed invention cannot be diversely aimed invention cannot be when the document is locuments, such combination art
A" document of particul E" earlier app L" document establish the specified) O" document priority da Date of the act 1 April 2004 Iame and mai Main P.O. Alexa	defining the general state of the art which is not considered to be lar relevance plication or patent published on or after the international filing date which may throw doubts on priority claim(s) or which is cited to the publication date of another citation or other special reason (as referring to an oral disclosure, use, exhibition or other means published prior to the international filing date but later than the see claimed citual completion of the international search (21.04.2004) illing address of the ISA/US Stop PCT, Atm: ISA/US missioner for Patents	"X" document of part considered novel when the document of part considered to inv combined with or being obvious to document member of mailing of the in Authorized officer	ublished after the interronflict with the applicative underlying the inventicular relevance; the classical relevance; the classical relevance; the classical relevance; the classical relevance; the classical relevance; the classical relevance; the classical relevance; the classical relevance in the same patent fair of the same patent fair relevance relevance.	aimed invention cannot be d to involve an inventive step aimed invention cannot be did to involve an inventive step aimed invention cannot be when the document is locuments, such combination art mily